

Repeatability Evaluation of Direct-Write Printing on Flexible and Three-Dimensional Geometries

Completed Technology Project (2014 - 2018)



Project Introduction

This restart and expansion of the FY17 effort seeks to refine the team's capability to 3D print a variety of sensors, wire connectors, and related devices at micron scale. Previous efforts demonstrated feasibility, but the techniques still require significant refinement in order to demonstrate repeatability. For FY18 the focus will be on validating the survivability of printed flexible readout strips during assembly and testing, and printing conformal conductive (and superconductive) traces over large-area assemblies and three-dimensional shapes. This effort supports such flight programs as PRaXyS and the Next Generation of X-ray Polarimeter (NGxP). For example, the current SAO for the NGxT detector is at a pitch of 121 micron. This direct write technology should reduce the pitch to 60 micros, thus increasing sensitivity by 3x. The FY18 effort will also investigate printing of Al superconducting inks. A key goal is 3D printing of the sensor assemblies by the end of the FY.

Anticipated Benefits

This project seeks to focus on the need for more dense and compact electronic and detector assemblies. This is addressed through the application of direct-write additive manufacturing of electronic circuitry. As this is a new technology, development of reliable processes which insure repeatable results in fabrication is a significant issue, which is addressed via this CIF.

Primary U.S. Work Locations and Key Partners

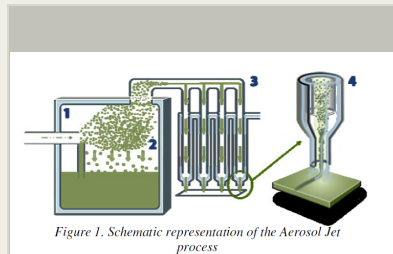
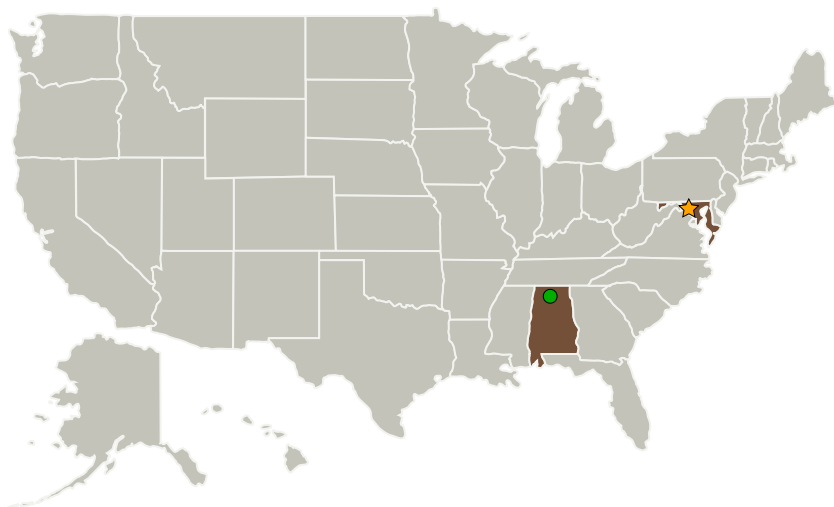


Figure 1. Schematic representation of the Aerosol Jet process

Aerosol Jet Additive Manufacturing of High Density Printed Circuits on Complex Geometries Project

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Organizations Performing Work	Role	Type	Location
★Goddard Space Flight Center(GSFC)	Lead Organization	NASA Center	Greenbelt, Maryland
Georgia Institute of Technology-Main Campus(GA Tech)	Supporting Organization	Academia	Atlanta, Georgia
Laboratory for Physical Sciences	Supporting Organization	Industry	
●Marshall Space Flight Center(MSFC)	Supporting Organization	NASA Center	Huntsville, Alabama
NanoDirect LLC	Supporting Organization	Industry	Baltimore, Maryland
National Institute of Standards and Technology(NIST)	Supporting Organization	US Government	Boulder, Colorado
Optomec Inc	Supporting Organization	Industry	Albuquerque, New Mexico
Quest Integrated, LLC	Supporting Organization	Industry Small Disadvantaged Business (SDB)	Kent, Washington
Raytheon Company	Supporting Organization	Industry	
Sun Chemical	Supporting Organization	Industry	New Jersey

Continued on following page.

Organizational Responsibility

Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

Lead Center / Facility:

Goddard Space Flight Center (GSFC)

Responsible Program:

Center Innovation Fund: GSFC CIF

Project Management

Program Director:

Michael R Lapointe

Program Manager:

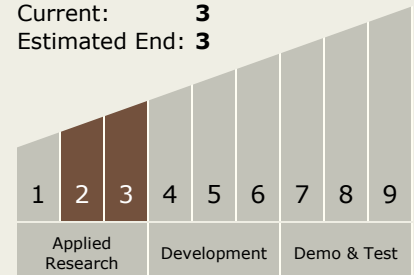
Peter M Hughes

Principal Investigator:

Beth M Paquette

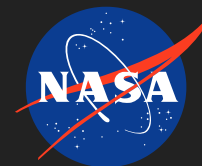
Technology Maturity (TRL)

Start: **2**
 Current: **3**
 Estimated End: **3**



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Organizations Performing Work	Role	Type	Location
United Technologies Research Center	Supporting Organization	Industry	
University of Delaware	Supporting Organization	Academia	Newark, Delaware
University of Massachusetts-Lowell	Supporting Organization	Academia	Lowell, Massachusetts

Co-Funding Partners	Type	Location
Air Force Research Laboratory(AFRL)	US Government	Notre Dame, Indiana
Applied Nanotech, Inc.	Industry	Austin, Texas
NanoDirect LLC	Industry	Baltimore, Maryland
National Institute of Standards and Technology(NIST)	US Government	Boulder, Colorado
nScript, Inc.	Industry	Orlando, Florida
Optomec Inc	Industry	Albuquerque, New Mexico
Raytheon Company	Industry	
Sun Chemical	Industry	New Jersey
United Technologies Research Center	Industry	

Primary U.S. Work Locations

Alabama	Maryland
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Technology Areas

Primary:

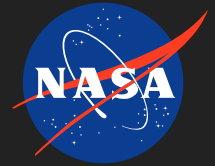
- TX12 Materials, Structures, Mechanical Systems, and Manufacturing
 - TX12.4 Manufacturing
 - TX12.4.1 Manufacturing Processes

Target Destinations

The Moon, Mars, Earth

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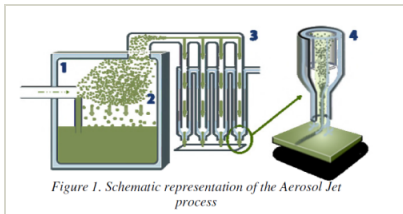


Project Transitions

**October 2014:** Project Start**September 2018:** Closed out

Closeout Summary: There are unknowns in available conductive inks as well as direct-write printing setup and printing processes, which make repeatable results difficult. The repeatability plans developed in this effort will identify processes we can use so that we always achieve our expected results. These plans identify: 1) the applications of focus; 2) requirements for the applications; 3) a process to select inks and other items based on those requirements and on what is already known about the inks or process to develop new inks; and 4) verification that requirements are met by printing. Plans were followed to print interconnects, which include an insulating ramp and conductive lines over the insulating ramp. Practice runs were performed and tested successfully. When the print was performed on the actual chip, the conductive lines were broken. Lessons learned were gathered from this print and incorporated into the printing plan. Such lessons included additional alignment checks and added passes of conductive lines to make them more robust. A separate plan was followed to print a detector pattern. Several detector patterns were printed on a variety of substrates, and survived functional testing in the detector chamber.

Images



Aerosol Jet Additive Manufacturing of High Density Printed Circuits on Complex Geometries Project

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(<https://techport.nasa.gov/image/16534>)

Links

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3D Aerosol Jet® Printing - Adding Electronics Functionality to RP/RM

(http://www.optomec.com/wp-content/uploads/2014/04/Optomec_NEOTECH_DDMC_3D_Aerosol_Jet_Printing.pdf)

GSC-17553-1

(no url provided)

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GSC-17686-1
(no url provided)

Project Website:

https://www.nasa.gov/directorates/spacetech/innovation_fund/index.html#.VQb6gUjJzyE